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Koskela et al.

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(54) **EFFICIENT ENABLEMENT FOR WIRELESS COMMUNICATION ON LICENSE-EXEMPT BANDS**

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H04W 48/10	(2009.01)
H04W 16/14	(2009.01)
H04W 72/02	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 72/005*** (2013.01); ***H04W 16/14*** (2013.01); ***H04W 48/10*** (2013.01); *H04W 72/02* (2013.01)

(58) **Field of Classification Search**

CPC H04W 72/0493; H04W 72/10
USPC 455/3.01, 419, 67.11, 420, 434, 450, 455/3.03, 414.1, 452.1, 458, 509; 370/312, 370/278, 336, 329, 252

See application file for complete search history.

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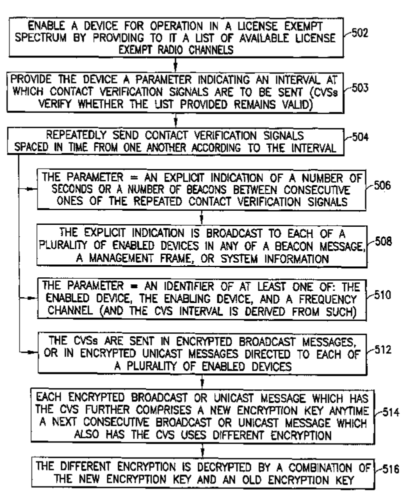
(57) **ABSTRACT**

A fixed or Mode II device enables a Mode I device for license exempt operation by providing to it a list of available license exempt radio channels and a parameter indicating an interval at which contact verification signals CVSs are to be sent. The CVSs verify whether the list remains valid. The fixed/Mode II device then repeatedly sends contact verification signals spaced in time from one another according to the interval. In various embodiments the parameter may be an explicit indication, or it may be implicit. A plurality of enabled Mode I devices each gets a device-specific list, and in one embodiment the interval is the same for each of them and the explicit indication is broadcast while in another the parameter is provided to each of them via unicast messages and the interval may differ.

20 Claims, 6 Drawing Sheets



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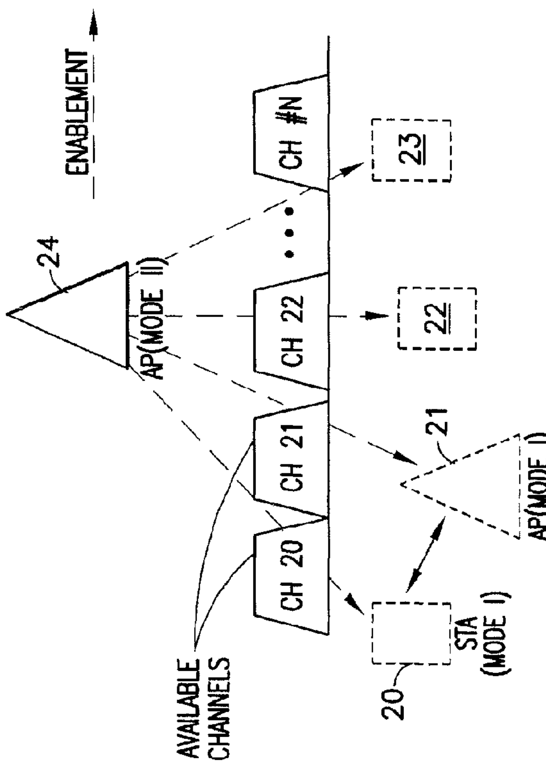

FIG.1

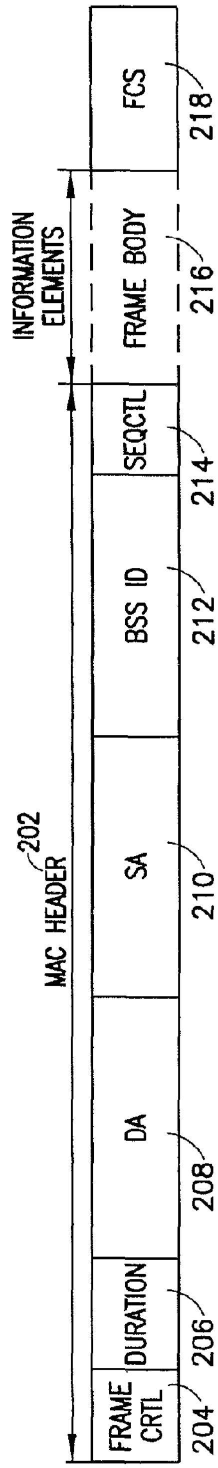

FIG.2

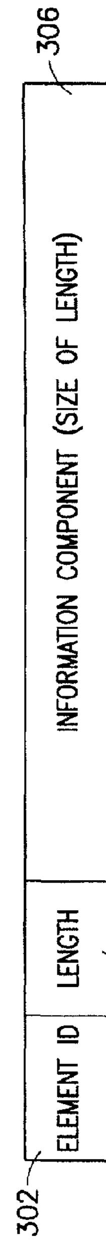

FIG.3

SystemInformationBlockType1 message

```
-- ASN1START
SystemInformationBlockType1 ::=         SEQUENCE {
    cellAccessRelatedInfo               SEQUENCE {
        plmn-IdentityList                   PLMN-IdentityList,
        trackingAreaCode                    TrackingAreaCode,
        cellIdentity                        CellIdentity,
        cellBarred                          ENUMERATED {barred, notBarred},
        intraFreqReselection                ENUMERATED {allowed, notAllowed},
        csg-Indication                      BOOLEAN,
        csg-Identity                        CSG-Identity          OPTIONAL   -- Need OR
    },
    cellSelectionInfo                   SEQUENCE {
        q-RxLevMin                          Q-RxLevMin,
        q-RxLevMinOffset                    INTEGER (1..8)        OPTIONAL   -- Need OP
    },
    p-Max                               P-Max                     OPTIONAL,  -- Need OP
    freqBandIndicator                   INTEGER (1..64),
    schedulingInfoList                  SchedulingInfoList,
    tdd-Config                          TDD-Config                OPTIONAL,  -- Cond TDD
    si-WindowLength                     ENUMERATED {
                                            ms1, ms2, ms5, ms10, ms15, ms20, ms40},
    systemInfoValueTag                  INTEGER (0..31),
    nonCriticalExtension                SystemInformationBlockType1-v890-IEs   OPTIONAL
}
SystemInformationBlockType1-v890-IEs ::= SEQUENCE {
        lateNonCriticalExtension        OCTET STRING              OPTIONAL,  -- Need OP
        nonCriticalExtension            SystemInformationBlockType1-v920-IEs   OPTIONAL
```

FIG.4A

FIG.4A
FIG.4B

FIG.4

```
}
SystemInformationBlockType1-v920-IEs ::= SEQUENCE {
        ims-EmergencySupport-r9        ENUMERATED {true}           OPTIONAL,   -- Need OR
        cellSelectionInfo-v920         CellSelectionInfo-v920      OPTIONAL,   -- Cond RSRQ
        nonCriticalExtension           SEQUENCE { }                OPTIONAL    -- Need OP
}
PLMN-IdentityList ::=                  SEQUENCE (SIZE (1..6)) OF PLMN-IdentityInfo
PLMN-IdentityInfo ::=                  SEQUENCE {
        plmn-Identity                      PLMN-Identity,
        cellReservedForOperatorUse         ENUMERATED {reserved, notReserved}
}
SchedulingInfoList ::=                 SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo
SchedulingInfo ::=                     SEQUENCE {
        si-Periodicity                 ENUMERATED {
                                           rf8, rf16, rf32, rf64, rf128, rf256, rf512},
        sib-MappingInfo                SIB-MappingInfo
}
SIB-MappingInfo  ::=                   SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type
SIB-Type  ::=                          ENUMERATED {
                                           sibType3, sibType4, sibType5, sibType6,
                                           sibType7, sibType8, sibType9, sibType10,
                                           sibType11, sibType12-v920, sibType13-v920, spare5,
                                           spare4, spare3, spare2, spare1, ... }
CellSelectionInfo-v920 ::=             SEQUENCE {
        q-QualMin-r9                       Q-QualMin-r9,
        q-QualMinOffset-r9                 INTEGER (1..8)          OPTIONAL   -- Need OP
}
-- ASN1STOP
```

FIG.4B

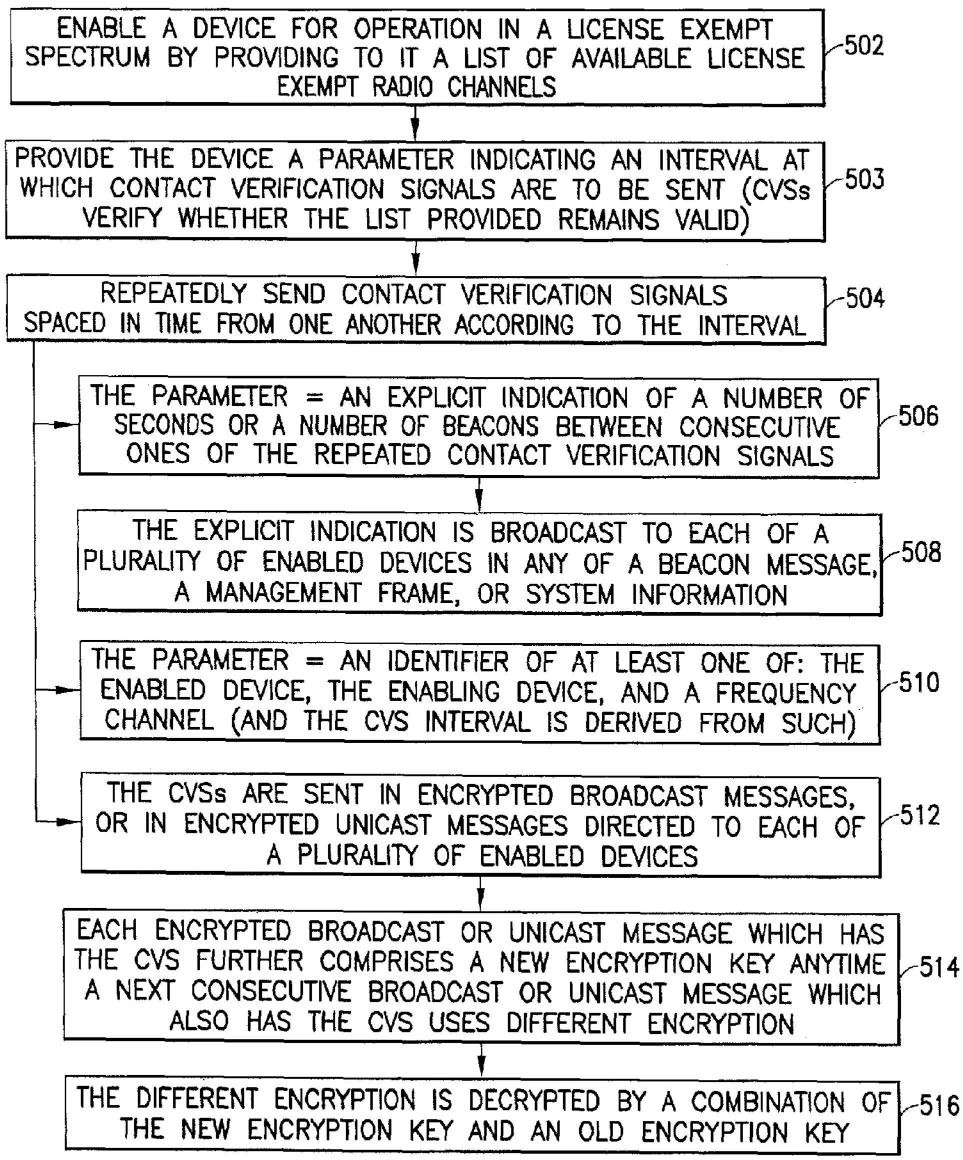
ENABLE A DEVICE FOR OPERATION IN A LICENSE EXEMPT SPECTRUM BY PROVIDING TO IT A LIST OF AVAILABLE LICENSE EXEMPT RADIO CHANNELS
502
PROVIDE THE DEVICE A PARAMETER INDICATING AN INTERVAL AT WHICH CONTACT VERIFICATION SIGNALS ARE TO BE SENT (CVSs VERIFY WHETHER THE LIST PROVIDED REMAINS VALID)
503
REPEATEDLY SEND CONTACT VERIFICATION SIGNALS SPACED IN TIME FROM ONE ANOTHER ACCORDING TO THE INTERVAL
504
THE PARAMETER = AN EXPLICIT INDICATION OF A NUMBER OF SECONDS OR A NUMBER OF BEACONS BETWEEN CONSECUTIVE ONES OF THE REPEATED CONTACT VERIFICATION SIGNALS
506
THE EXPLICIT INDICATION IS BROADCAST TO EACH OF A PLURALITY OF ENABLED DEVICES IN ANY OF A BEACON MESSAGE, A MANAGEMENT FRAME, OR SYSTEM INFORMATION
508
THE PARAMETER = AN IDENTIFIER OF AT LEAST ONE OF: THE ENABLED DEVICE, THE ENABLING DEVICE, AND A FREQUENCY CHANNEL (AND THE CVS INTERVAL IS DERIVED FROM SUCH)
510
THE CVSs ARE SENT IN ENCRYPTED BROADCAST MESSAGES, OR IN ENCRYPTED UNICAST MESSAGES DIRECTED TO EACH OF A PLURALITY OF ENABLED DEVICES
512
EACH ENCRYPTED BROADCAST OR UNICAST MESSAGE WHICH HAS THE CVS FURTHER COMPRISES A NEW ENCRYPTION KEY ANYTIME A NEXT CONSECUTIVE BROADCAST OR UNICAST MESSAGE WHICH ALSO HAS THE CVS USES DIFFERENT ENCRYPTION
514
THE DIFFERENT ENCRYPTION IS DECRYPTED BY A COMBINATION OF THE NEW ENCRYPTION KEY AND AN OLD ENCRYPTION KEY
516

FIG.5

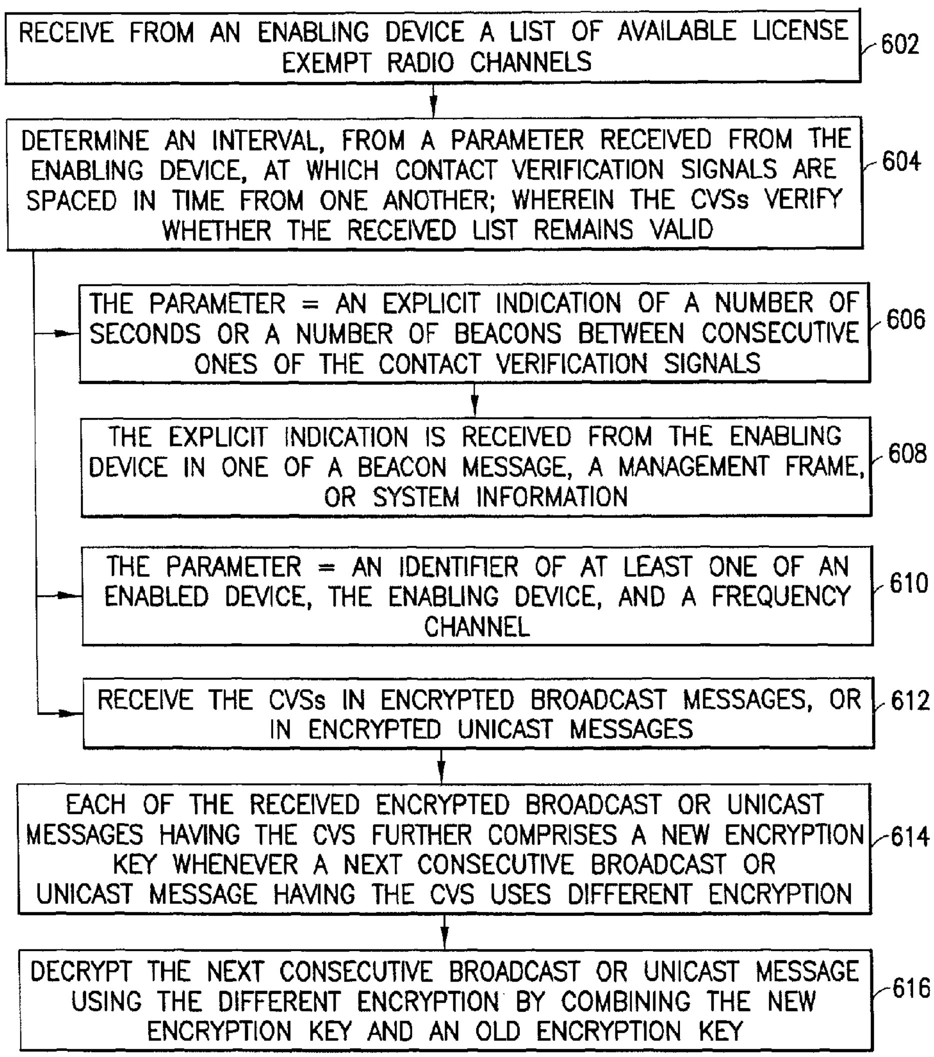
RECEIVE FROM AN ENABLING DEVICE A LIST OF AVAILABLE LICENSE EXEMPT RADIO CHANNELS
602
DETERMINE AN INTERVAL, FROM A PARAMETER RECEIVED FROM THE ENABLING DEVICE, AT WHICH CONTACT VERIFICATION SIGNALS ARE SPACED IN TIME FROM ONE ANOTHER; WHEREIN THE CVSs VERIFY WHETHER THE RECEIVED LIST REMAINS VALID
604
THE PARAMETER = AN EXPLICIT INDICATION OF A NUMBER OF SECONDS OR A NUMBER OF BEACONS BETWEEN CONSECUTIVE ONES OF THE CONTACT VERIFICATION SIGNALS
606
THE EXPLICIT INDICATION IS RECEIVED FROM THE ENABLING DEVICE IN ONE OF A BEACON MESSAGE, A MANAGEMENT FRAME, OR SYSTEM INFORMATION
608
THE PARAMETER = AN IDENTIFIER OF AT LEAST ONE OF AN ENABLED DEVICE, THE ENABLING DEVICE, AND A FREQUENCY CHANNEL
610
RECEIVE THE CVSs IN ENCRYPTED BROADCAST MESSAGES, OR IN ENCRYPTED UNICAST MESSAGES
612
EACH OF THE RECEIVED ENCRYPTED BROADCAST OR UNICAST MESSAGES HAVING THE CVS FURTHER COMPRISES A NEW ENCRYPTION KEY WHENEVER A NEXT CONSECUTIVE BROADCAST OR UNICAST MESSAGE HAVING THE CVS USES DIFFERENT ENCRYPTION
614
DECRYPT THE NEXT CONSECUTIVE BROADCAST OR UNICAST MESSAGE USING THE DIFFERENT ENCRYPTION BY COMBINING THE NEW ENCRYPTION KEY AND AN OLD ENCRYPTION KEY
616

FIG.6

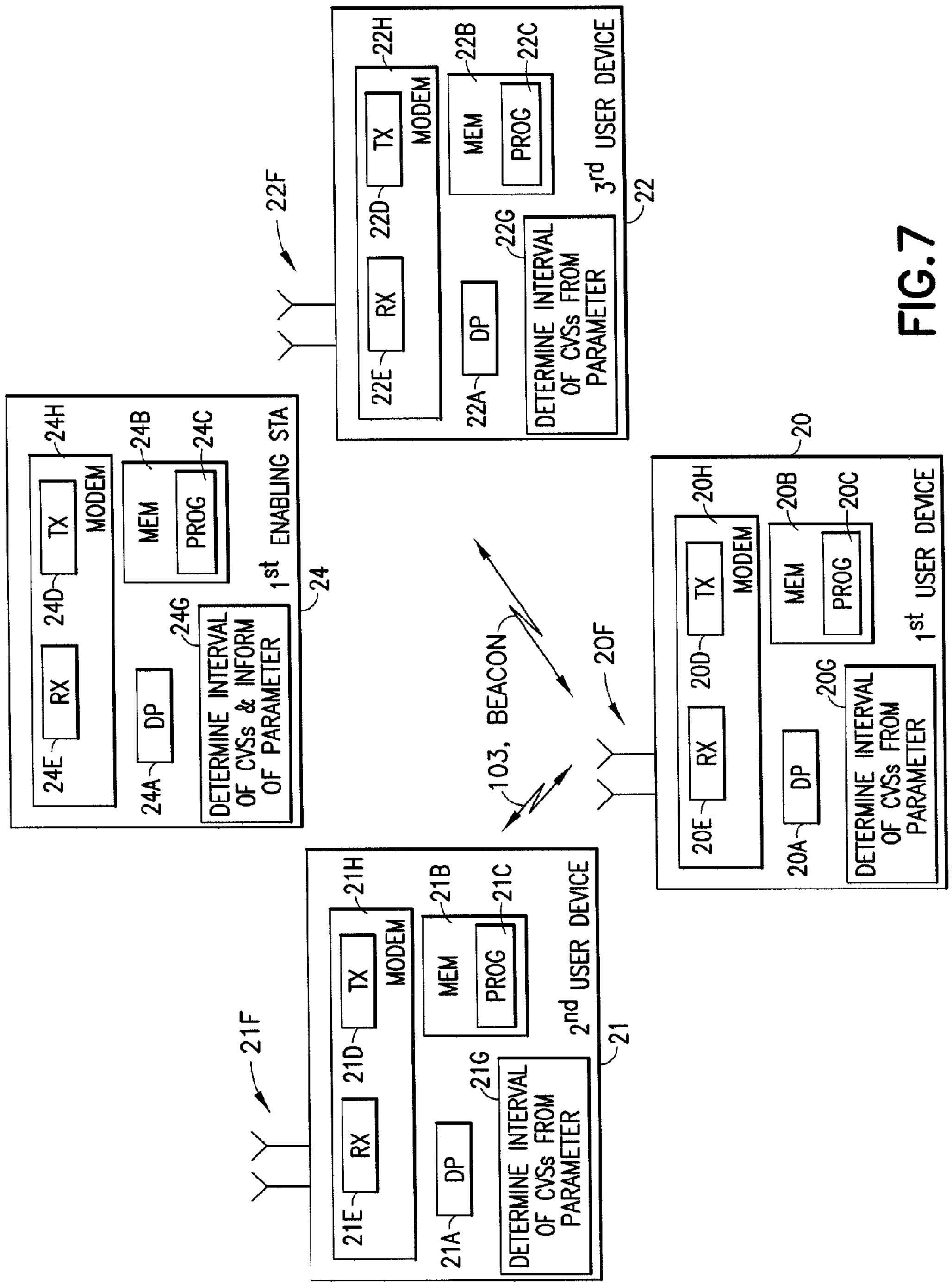
1st ENABLING STA
24
24H
24E
RX
24D
TX
MODEM
24B
MEM
24C
PROG
24A
DP
24G
DETERMINE INTERVAL OF CVSs & INFORM OF PARAMETER
3rd USER DEVICE
22
22F
22H
22E
RX
22D
TX
MODEM
22B
MEM
22C
PROG
22A
DP
22G
DETERMINE INTERVAL OF CVSs FROM PARAMETER
2nd USER DEVICE
21
21F
21H
21E
RX
21D
TX
MODEM
21B
MEM
21C
PROG
21A
DP
21G
DETERMINE INTERVAL OF CVSs FROM PARAMETER
1st USER DEVICE
20
20F
20H
20E
RX
20D
TX
MODEM
20B
MEM
20C
PROG
20A
DP
20G
DETERMINE INTERVAL OF CVSs FROM PARAMETER
103, BEACON

FIG.7

EFFICIENT ENABLEMENT FOR WIRELESS COMMUNICATION ON LICENSE-EXEMPT BANDS

CROSS REFERENCE TO RELATED APPLICATION

Subject matter detailed herein is related to that detailed at co-owned U.S. patent application Ser. No. 13/184,702, filed on Jul. 18, 2011 and entitled 'Wireless Network Operation on License-Exempt Band". That related application is herein incorporated in its entirety.

TECHNICAL FIELD

The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, relate to techniques and procedures for keeping devices enabled for communication over available license-exempt channels.

BACKGROUND

The following abbreviations that may be found in the specification and/or the drawing figures are defined as follows:

CVS contact verification signal
DA destination address
E-UTRAN evolved UMTS terrestrial radio access network
FCC Federal Communications Commission
IBSS independent basic service set
ID identifier
IEEE Institute for Electrical and Electronics Engineers
MAC medium access control
RX receive
SA sender address
SSID service set identifier
TVBD television band device
TVWS television white spaces
TX transmit
WLAN wireless local area network

To alleviate congestion in conventional cellular spectrum, research has turned recently to exploiting license-exempt radio spectrum such as the industrial, scientific and medical (ISM) band and what in the United States are known as TVWS, which is a particular portion of the license-exempt spectrum which was at one time set aside for television broadcast but which in recent years has become increasingly available for other radio communications. In general license-exempt radio spectrum is sometimes referred to as a shared band, contrasted with conventional cellular systems which utilize radio spectrum for which the system operator holds a license from a government regulator such as the FCC in the United States. Administration of wireless operations on such license-exempt bands is quite country-specific at least at this early stage, with the FCC implementing regulations for use of the TVWS in the United States.

In the United States it is envisioned that there will be whitespace or TV band databases indicating, for specific geographic areas or geo-locations, which portions of that license-exempt spectrum are available to parties other than those involved with television broadcasting. Such portions may be identified in the relevant database as indexed channels, bandwidth and center frequency, upper and lower frequency bounds, or other frequency-definitive parameters.

Relevant to TVWS in the United States, the FCC defines two concepts for aiding users in finding available channels; a TV bands database as summarized above and the geo-location capability. See for example document FCC 10-174; SECOND MEMORANDUM OPINION AND ORDER; UNLICENSED OPERATION IN THE TV BROADCAST BANDS—ADDITIONAL SPECTRUM FOR UNLICENSED DEVICES BELOW 900 MHz AND IN THE 3 GHz BAND (adopted and released Sep. 23, 2010). The TV band database is to maintain records of all authorized services in the TV frequency bands and so is capable of determining the available channels as a specific geographic location. Such available (or equivalently the used) channels are provided as lists to TVBSs that have been certified under the FCC's equipment authorization procedures. Some of the TVBDs will have a geo-location capability, and those devices should be able to determine their own geographic coordinates within a certain level of accuracy (+/−50 m). This capability is used with a TV bands database to determine the availability of TV channels at a TVBD's geo-location. The FCC defines several types of TVBDs as follows based on those devices' characteristics.

A fixed TVBD is located at a specified fixed location and has the following functions/capabilities: it can select a channel from the TV bands database; it can initiate and operate a network (by sending enabling signals to other fixed TVBDs and/or personal/portable TVBDs); and it can provide to a Mode I personal/portable device (see below) a list of available channels on which the Mode I device may operate (currently, above TV channel 20) and a supplemental list of available channels for Mode I devices (these available channels are adjacent to occupied TV channels and are those on which a fixed TVBD cannot operate). Examples of what may operate as a fixed TVBD in the LTE system include an access node/eNodeB, a mobility management entity MME, a serving gateway S-GW, a local gateway L-GW, and a packet gateway P-GW. Similarly functioning nodes in other radio access networks may also serve the functions of a fixed TVBD. The maximum power a fixed TVBD is allowed to deliver to its TX antenna shall not exceed 1 W, and the maximum power spectral density (any 100 kHz during any time interval of continuous transmission) is 12.2 dBm.

A Mode I personal/portable device is another of the FCC's TVBD types. This type does not use any internal geo-location capability it may have (if any) to find its TVWS channels so even if it can access a TV bands database the mode I device must obtain its channel list from either a fixed TVBD or from a Mode II personal/portable TVBD (see below). A Mode I device may operate only as a client or dependent station/device, but not as an enabling station/device.

A Mode II personal/portable device is a portable device having similar functions as a fixed TVBD, but does not need to transmit/receive signals at a specified and fixed place. For personal/portable TVBDs, the maximum effective isotropic radiated power (EIRP) is 100 mW (20 dBm). If the personal/portable TVBD does not meet the adjacent channel separation requirements (the distance between the TVBD and the TV station is smaller than the minimum distance requirement), the maximum EIRP is set to 40 mW (16 dBm). The maximum power spectral densities for personal/portable devices operating adjacent to occupied TV channels is −1.6 dBm, otherwise 2.2 dBm.

And finally the FCC has designated a sensing only device, which is a personal/portable TVBD that uses spectrum sensing to determine a list of available channels. It can use the frequency bands 512-608 MHz (TV channels 21-36) and 614-698 MHz (TV channels 38-51). Currently, the FCC defines spectrum sensing only for personal/portable TVBDs. The maximum power spectral density for sensing only devices is −0.8 dBm.

The IEEE 802.11af standard being drafted (D1.02; June 2011) is intended to amend the 802.11 specification for TVWS operation by, among other aspects, fulfilling the above requirements. The document FCC 10-174 cited above further requires that Mode I devices are to be enabled by a (fixed or) Mode II device (called enabling station), and then once enabled the Mode I device may start transmission on an available television channel or channels (more generally, a TVWS frequency resource).

A problem arises in the procedure for enabling a Mode I device. Having first obtained the list of available TVWS channels, the Mode I device must receive a CVS at least every 60 seconds to verify its list. Such as CVS signal is shown at reference number 412 of FIG. 4 in the above-referenced co-owned U.S. patent application Ser. No. 13/184,702. At §15.71 of the above referenced document FCC 10-174 the CVS is defined as follows:

> "(b) Contact verification signal. An encoded signal broadcast by a fixed or Mode II device for reception by Mode I devices to which the fixed or Mode II device has provided a list of available channels for operation. Such signal is for the purpose of establishing that the Mode I device is still within the reception range of the fixed or Mode II device for purposes of validating the list of available channels used by the Mode I device and shall be encoded to ensure that the signal originates from the device that provided the list of available channels. A Mode I device may respond only to a contact verification signal from the fixed or Mode II device that provided the list of available channels on which it operates. A fixed or Mode II device shall provide the information needed by a Mode I device to decode the contact verification signal at the same time it provides the list of available channels."

In practice the transmission interval of the CVS signal should be more frequent, because in case there is only one CVS transmission during a 60 second period a mode I device which misses it would have to stop operation on TVWS and get re-enabled before it can transmit again. Or if the 60 second time limit is approaching the Mode I can request CVS enablement from the Mode II device which originally provided the list, in which case the Mode II device does not have to track the 60 second timer for every device which it has enabled.

The FCC regulations provide that the Mode II device which provided the channel list for a Mode I device is also required to transmit CVS signaling to each of its enabled devices. But a given Mode II device may enable several Mode I devices on several different channels, and herein lies the problem which is illustrated by example at FIG. **1**.

There is a Mode II AP **24** which enables communication on several channels, shown by example as starting from channel #20 (Ch20) up to channel #N (Ch#N). The enablement may be non-contiguous meaning that certain channels between Ch20 and Ch#N will not be available at this particular location. By enabling multiple STAs **20**, **22**, **23** and potentially also APs (mode I APs) **21** on different channels, on different parts of spectrum, the enablement signaling load of Mode II AP increases. For multiple Mode I devices enabled by a single Mode II device, this is too high of a burden to the enabling device **24** which must frequently re-check the TVWS database and redistribute the channel list. The conventional procedure is also seen to be too high a burden on the enabled Mode I devices **20**-**23**.

Apart from the documents FCC 10-174 and IEEE 802.11af noted above, also relevant to these teachings are:

- document IEEE 802.11-11/908r1 entitled "Secure Enablement and CVS without Persistent Association", by Qualcomm (Jul. 5, 2011);
- Section 8.3 of IEEE Draft P802.11-REVmb™/D8.01 (May 2011) concerning frame type formats; and
- 3GPP TS 36.331 V10.2.0 (2011-06) (Release 10).

SUMMARY

In a first exemplary embodiment of the invention there is an apparatus comprising at least one processor and at least one memory storing a computer program. In this embodiment the at least one memory with the computer program is configured with the at least one processor to cause the apparatus to at least: enable a device for operation in a license exempt spectrum by providing to the device a list of available license exempt radio channels; provide to the device a parameter indicating an interval at which contact verification signals are to be sent, in which the contact verification signals verify whether the list remains valid and repeatedly send contact verification signals spaced in time from one another according to the interval.

In a second exemplary embodiment of the invention there is a method comprising: enabling a device for operation in a license exempt spectrum by providing to the device a list of available license exempt radio channels; providing to the device a parameter indicating an interval at which contact verification signals are to be sent, in which the contact verification signals verify whether the list remains valid; and repeatedly sending contact verification signals spaced in time from one another according to the interval.

In a third exemplary embodiment of the invention there is a computer readable memory storing a computer program, in which the computer program comprises: code for enabling a device for operation in a license exempt spectrum by providing to the device a list of available license exempt radio channels; code for providing to the device a parameter indicating an interval at which contact verification signals are to be sent, in which the contact verification signals verify whether the list remains valid; and code for repeatedly sending contact verification signals spaced in time from one another according to the interval.

In a fourth exemplary embodiment of the invention there is an apparatus comprising at least one processor and at least one memory storing a computer program. In this embodiment the at least one memory with the computer program is configured with the at least one processor to cause the apparatus to at least: receive from an enabling device a list of available license exempt radio channels; and determine an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, in which the contact verification signals verify whether the received list remains valid.

In a fifth exemplary embodiment of the invention there is a method comprising: receiving from an enabling device a list of available license exempt radio channels; and determining an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, in which the contact verification signals verify whether the received list remains valid.

In a sixth exemplary embodiment of the invention there is a computer readable memory storing a computer program, in which the computer program comprises: code for receiving from an enabling device a list of available license exempt radio channels; and code for determining an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, in which the contact verification signals verify whether the received list remains valid.

These and other embodiments and aspects are detailed below with particularity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of a single Mode II device enabling four Mode I devices on different TVWS channels, and illustrates an environment in which embodiments of the invention may be practiced to advantage.

FIG. **2** is a schematic diagram showing the frame structure of a conventional management frame in an IEEE 802.11af radio access system.

FIG. **3** is a schematic diagram showing the conventional structure of a generic variable length information element disposed in the frame body of the FIG. **2** management frame which may be adapted to include the CVS information detailed herein.

FIG. **4**, illustrated as FIG. **4**A and FIG. **4**B, is a conventional system information block in an E-UTRAN/LTE system which may be extended according to these teachings to include the CVS information detailed herein.

FIG. **5** is a logic flow diagram that illustrates the operation of a method, and a result of execution of computer program instructions embodied on a computer readable memory, from the perspective of the enabling device **24** of FIG. **1** in accordance with the exemplary embodiments of this invention.

FIG. **6** is a logic flow diagram that illustrates the operation of a method, and a result of execution of computer program instructions embodied on a computer readable memory, from the perspective of an enabled device **20**-**23** of FIG. **1** in accordance with the exemplary embodiments of this invention.

FIG. **7** is a simplified block diagram of various devices shown at FIG. **1**, which are exemplary electronic devices suitable for use in practicing the exemplary embodiments of the invention.

DETAILED DESCRIPTION

While the exemplary embodiments detailed below are in the context of WLAN and other similar ad hoc networks, these teachings apply also to other structured radio access technologies such as for example global system for mobile communication (GSM), universal terrestrial radio access network (UTRAN), evolved UTRAN (E-UTRAN), and their future evolutions. Since the terminology for the various devices may be country specific, the FCC Mode II device is more generally termed an enabling device and an FCC fixed device may also operate as an enabling device; the FCC Mode I device is more generally termed an enabled device; and the TVWS is more generally referred to as license exempt bands or channels.

First consider the scenario by which the first enabled device **20** of FIG. **1** becomes enabled by the enabling device **24** (though the same applies to any of the enabled devices **20**-**23**). In the WLAN or ad hoc context the enabled devices **20**-**23** are operating as (non-access point) stations STA and the enabling device is operating as an access point AP. It is notable that the different enabled devices **20**-**23** may be enabled for different license exempt channels as shown at FIG. **1**; having them all enabled for the same license-exempt channel is likely to result in interference or undue delay when they all compete for resources using some contention procedure.

After authentication and association the first enabled device **20** receives encryption keys for the CVS reception from the enabling device **24**. The first enabled device **20** will not stay associated since it may have no data but wishes to remain enabled. Some reasons it may wish to remain enabled despite having no data to send is to operate on the unlicensed band (for example, set up an IBSS network), or to connect to an access point which is also a mode I device (such as the Mode I device **21** which is a WLAN AP for other WLAN devices/stations **20**, **22** in its coverage area and which is enabled by the enabling device **24**) area), or to setup communications quickly after going into a sleep mode.

According to an exemplary embodiment of these teachings, the enabling device transmits an indication of the CVS transmission periodicity. This indication of the CVS interval may be broadcast in the enabling device's beacon message, or it may be transmitted in a management frame such as for example an action frame or in the enabling device's broadcast system information. Depending on the type of management frame they may be broadcasted or unicasted. In one embodiment the CVS interval is the same for all of the enabled devices, and this embodiment is most easily implemented if the parameter indicating the CVS interval is broadcast; in another embodiment the CVS interval is different for at least two of the enabled devices (or at least the CVS interval is not necessarily the same for them all), and this embodiment is most easily implemented if the parameter indicating the CVS interval is sent to the enabled devices via individual unicast messages. In various implementations this CVS interval may be expressed as a clock measurement such as a number of milliseconds, or as a system frame measurement such as a number of beacons between CVS transmissions. So while the enabling device **24** can enable the various enabled devices **20**-**23** on multiple and/or different license exempt channels, the enabling device **24** needs to transmit the CVS interval indication on only one channel and that indicated CVS interval is valid for all the channels which the enabling device **24** has included in the Available Channel List which the enabling device **24** most recently provided to all its various enabled devices **20**-**23**. For the case in which there is a single CVS interval for all of the devices, it is valid for all the channels which the enabling device **24** has included in the all of the Available Channel Lists which it provided to the various plurality of enabled devices **20**-**23**.

In one exemplary embodiment, the enabling device **24** also indicates the specific channel or channels on which it will send the CVS transmission or transmissions. That is, the CVS transmission may configure a specific one (or more) of the enabled devices **20**-**23** for a specific channel on which that enabled device(s) is to receive its CVS transmission. Even if there are multiple CVS transmissions to different devices on different channels, all such CVS transmissions from the enabling device **24** follow the CVS interval which is indicated on one channel that all the devices can access. So any given device **20**-**23** which desires to become or to remain enabled, but has no immediate need to transmit its own data, can read the CVS interval indication from the enabling device's **24** beacon (or system information or other management/action frame) and go into a reduced power/sleep mode for a relatively extended period of time. In this manner the enabled devices **20**-**23** are able to forego checking every beacon from the enabling device **24** and need not be awake for every CVS transmission from the enabling device **24**.

A Mode I device **20-23** which is enabled by a Mode II device **24** may obtain the CVS interval from the Mode II device **24** and, in one non-limiting embodiment, may further repeat the Mode II CVS interval information (parameter) in its own broadcast transmission. This is especially useful for the case of an ad hoc network in which the Mode II device **24** sets the same CVS interval for all of its enabled devices **20-23**. But in this case the Mode I device repeating the CVS interval information does not re-send the content of the CVS message itself, only the parameter indicating the CVS interval.

The various implementations of the indicated CVS interval mentioned above (number of milliseconds, number of beacons) imply an explicit indication. In other exemplary embodiments the indication can be implicit. For example, the CVS interval may be derived by the various involved devices **20-24** utilizing the device ID given by the network/enabling device **24**. In one implementation of this the CVS transmission may be an encrypted broadcast message, and the CVS interval may be derived by applying a function to the access point/enabling device ID and the frequency channel ID. In this case it is efficient for the enabling device **24** to make the CVS interval identical for all of the enabled devices **20-23**. In another implementation the CVS transmission is an encrypted unicast message and the CVS interval is derived from the receiving device ID (e.g., the ID of the enabled device **20-23** addressed by the unicast message). If encrypted broadcasting is not supported by the network (which is the case presently with WLAN systems) this embodiment can be used, where the network would then use dedicated signaling to get the encrypted CVS messages to the individual enabled devices **20-23** and the CVS interval is not necessarily identical for all of those enabled devices **20-23** (though if for example a modulo operation is used on the device ID it may be that some but not all enabled devices get identical CVS intervals). In a still further implementation the CVS transmission interval is derived from any combination of the access point ID, the device ID, and the frequency channel ID. Such a device ID may be implemented as a temporary one assigned by the network, such as an association ID for WLAN networks, radio network temporary ID (RNTI) in LTE, and other such network assigned identifiers in other radio access technologies.

The above explicit and implicit implementations can be generalized as the enabling device **24** repeatedly sending CVSs, spaced in time from one another, according to a single interval, in which that interval is indicated by a parameter the enabling device **24** sends to each of the enabled devices **20-23**. For the explicit indication the parameter is that explicit indication, which as above may indicate a number of seconds or a number of beacons between consecutive ones of the repeated CVSs. In a most general sense, it is the network/enabling device **24** which configures the CVS interval, as opposed to the conventional FCC rule noted in the background section above which simply mandates a CVS be received by the enabled devices at least once every 60 seconds.

For the implicit indication the parameter may be one or any combination of an identifier an individual one of the plurality of the enabled devices **20-23**, an identifier the enabling device **24**, and/or an identifier of a frequency channel. These parameters are then inserted into some predetermined function (such as for example a modulo function on the whole identifier or on certain predetermined most or least significant bits thereof) known in advance to both the enabling device **24** and the enabled devices **20-23** (such as may be published in a wireless protocol/standard and locally stored at the various devices **20-24**) to derive the interval. For the case of the enabled device ID this is sent in a unicast message; for the case of the enabling device ID this is sent in its system information or possibly also in its beacon; for the case of the frequency channel ID this may be the ID of the channel on which the beacon is sent (and so communicated to the enabled devices **20-23** in system information for example). As another example of the frequency channel ID, the relevant channel may be that over which the CVS signal itself is provided by the Mode II device **24**. IN the WLAN system the channels are identified by index numbers, other non-WLAN implementations can use a similar channel index number or other identifier number assigned by the network. Or the network may instead use an ID obtained from combining two or more individual TVWS channels.

In the various implementations above, or any which use an encrypted message for the CVS signal, it is preferable that the encryption be changed from time to time so as to retain its security features. To this end the enabling device **24** provides a new encryption key each time it changes the encryption, and the enabling device **24** provides each new encryption key with the current CVS signal itself just before making the change.

For the above aspects of these embodiments in which there is a change to the encryption key, the key change can be triggered periodically by the enabling device **24** which tracks this via a timer (either a single timer if the CVS interval is the same for all enabled devices **20-23** or multiple timers if there are multiple different CVS intervals running concurrently); if the key has not been changed when the timer expires then expiry of the timer will cause the enabling device **24** to change the encryption. Any time the key is changed, in an embodiment the enabling device **24** will send the current CVS signal with the new key multiple times to better assure the affected enabled device or devices **20-23** are able to obtain it. Just in case any do not, then an enabled device **20-23** which did not obtain the new key can utilize the CVS request procedure (which was noted above in the context of its 60-second CVS timer nearing expiry) to obtain the new encryption key by utilizing the old encryption key. In this case the network/enabling device **24** can configure a validity time for the old key, and the old key used with such a CVS request procedure will be valid to obtain the new key only through the end of that validity time.

In an exemplary embodiment, anytime the enabling device **24** needs to update any enabled device's available channel list, the enabling device **24** will begin the key change procedure. But in other embodiments the key change may be up to the enabling device's discretion, and if a new key is only recently adopted when a channel list update occurs the enabling device **24** may choose not to re-issue a new encryption key.

The encryption keys may be specific per enabled device **20-23**. For example, if there is a specific channel list update request triggered by an individual enabled device **20-23** and that request is sent to a fixed enabling device, that fixed enabling device may begin the key change procedure for only that requesting enabled device, or may perform the key update procedure for all of the enabled devices which are using that same channel list which is being updated. In this context the specific channel list refers to a channel list that is only allowable for mode I/II devices, the license exempt available channel list which the mode II device gets from the TVWS database.

For added security in the key change procedure, the signaling to trigger the CVS key change can provide a new sequence which is not a decryption key in and of itself for the new encryption the enabling device **24** is about to use, but which is used together with the old key to derive the actual new decryption key. This derivation can also be a function known to the various devices **20-24** in advance, such as may be published in a wireless protocol/standard and locally stored in their respective memories. This implementation prevents the new decryption key from being sent over the air interface. Any of the enabled devices **20-23** can get the initial decryption key from the enabling device **24** at the time they obtain their initial channel list.

Since the above provisions for various exemplary embodiments have the network/enabling device **24** configuring the CVS interval rather than using some fixed value (e.g., 60 seconds) which applies regardless of which enabling device and traffic conditions, then the network/enabling device can in certain exemplary embodiments also configure the relevant timers in the enabled devices **20-23**. These include the timer which triggers a given enabled device **20-23** to send a request for a CVS, which for convenience is denoted as T_{CVRC}. The enabled devices **20-23** may need to send a CVS request for example if their decoding (or even decrypting) of the CVS fails and they do not wish to wait an additional interval to see if their allowed channel list is still valid.

By example, the network/enabling device **24** may take considerations of traffic and connectivity requirements of the current service into account when configuring the T_{CVRC} for the enabled devices, and/or may scale this timer with the amount of enabled devices **20-23** that are associated with (enabled by) the enabling device **24**. For implementations in which the CVS message is not broadcast by the enabling device **24** (for example, where encryption of broadcast messages is not supported by the system), the enabling device **24** may send the CVSs as unicast frames and set the interval a bit longer than if broadcasting were available, but given the FCC rule detailed in background above such longer interval should still be less than 60 seconds. In any case, the T_{CVRC} which the network/enabling device **24** configures for the enabled devices **20-23** should be greater than the CVS interval it configures and also less than 60 seconds.

For those embodiments in which the CVS is sent in a broadcast message, that same broadcast message may additionally carry information about the available channel list. If the channel list is changed the enabling device **24** will need to inform the enabled devices **20-23** that the channel list has changed, and in this embodiment can inform them also in that same CVS broadcast message. Once the list of available channels does change, the enabling device **24** will then broadcast the new channel list to the enabled devices **20-23** with the same encryption key but the message includes a new key (or new sequence used to derive the new key) which is used for the next encrypted broadcast with the CVS. If the CVS transmission is a broadcast message, the enabled devices **20-23** should not make unicast channel requests to the enabling device **24**.

FIG. **2** gives an example of a conventional MAC layer management frame under the 802.11 protocol which can be readily adapted with new information elements to implement the above embodiments concerning broadcasting the CVS signals. While FIGS. **2-3** are in the context of WLAN frames, similar implementations for other radio access technologies are readily adapted from these WLAN examples.

The 802.11 specifications provide for three basic frame types: control frames, data frames, and management frames. Management frames include, among others, beacon frames, public action frames, and action frames. Management frames have fixed headers and information is carried in the frame body in discrete information elements. FIG. **2** illustrates a management frame divided broadly into the frame header **202** and the frame body **216** which carries the information elements.

The header is divided into discrete fields. There is a frame control field **204** which indicates for example the protocol version and frame type (and possibly also frame subtype). There is a duration field **206** which indicates a duration value of the frame, how long it is. There is a DA field **208** which carries the destination MAC address and a SA field **210** which carries the sender MAC address. The header **202** also defines a BSS ID field **212** which carries the basic service set ID for the sender and a sequence control field **214** which contains values for the recipient to check for duplicate frames.

The frame body **216** carries the information elements and certain other fixed fields. Following the frame body **216** is a frame check sequence field **218** that carries a cyclic redundancy checksum of the whole frame. The frame body **216** consists of fixed length fields and variable length information element fields.

FIG. **3** illustrates a generic format for one information element field; there is an identifier field **302** to identify the particular information element, a length field **304** to indicate how long is the information element, and an information component **306** which carries the relevant information for that information element and whose size is governed by the length field **304**. In WLAN-specific embodiments of these teachings there may be an information element for the CVS, and which also includes the indication of the CVS interval for those implementations where that indication is explicit.

FIG. **4** gives an example of a System Information Block (SIB) Type 1 message, conventional for the E-UTRAN/LTE radio access technology, and taken from 3GPP 36.331 v 10.2.0 (2011-06). This conventional system information block (or master information block MIB) may be readily adapted/extended to implement the above embodiments concerning broadcasting the CVS related information. FIG. **4** is a non-limiting example; other types of system information blocks can be used to implement this aspect of the invention or a new system information block may be developed to do so. If not broadcast, for the E-UTRAN/LTE system the network/enabling device **24** can configure the UE specific parameters via dedicated radio resource control signaling.

For such a E-UTRAN/LTE implementation, there may additionally be signaling among the higher network node/mobility management entity (MME) and the eNodeB/enabling device **24** and the enabled devices **20-23** so as to implement the CVSs and the CVS interval indications detailed more fully above. For example, each logical entity could be defined to manage its own CVS related encryption keys, and this entity shall interact with the MME and possibly also the home subscriber service HSS of the particular enabled device **20-23**.

Embodiments of these teachings provide the technical effect of enabling an enhanced energy savings for the enabled devices **20-23**, as well as enabling an efficient multichannel operation by the enabling device **24**. Additionally, the enabled devices **20-23** are able to use the available channels indicated by the enabling device **24** without constantly monitoring their own enablement on a specific channel.

FIG. **5** is a logic flow diagram which describes an exemplary embodiment of the invention from the perspective of the enabling device **24**. FIG. **5** represents results from executing a computer program or an implementing algorithm stored in the local memory of the enabling device **24**, as well as illustrating the operation of a method and a specific manner in which the enabling device **24** (or one or more components thereof) are configured to cause that overall host electronic device to operate.

Blocks **502** and **504** concern distributing the available channel lists and the CVS interval, respectively. At block **502** a device is enabled for operation in a license-exempt radio spectrum/band by providing to it a list of available license exempt radio channels. Block **503** shows that the device is also provided a parameter indicating an interval at which contact verification signals are to be sent, in which the contact verification signals verify whether the list provided at block **502** remains valid. At block **504**, there is repeatedly sent contact verification signals spaced in time from one another according to the interval of block **503**.

Further portions of FIG. **5** are directed to certain of the above non-limiting embodiments and implementations. Block **506** tells that the parameter comprises an explicit indication of a number of seconds or a number of beacons between consecutive ones of the repeated contact verification signals. In the examples above there are a plurality of such enabled devices, and as stated at block **508**, such an explicit indication may be broadcast to the enabled device in any of a beacon message, a management frame, or system information.

Block **510** tells an alternative embodiment in which the parameter comprises an identifier of at least one of: the enabled device, the enabling device which is performing the elements of FIG. **5**, and a frequency channel. In this case the CVS interval is derived from one or more of those identifiers.

Remaining blocks of FIG. **5** relate to encryption. At block **512** the contact verification signals are sent in encrypted broadcast messages, or in encrypted unicast messages directed to each of a plurality of enabled devices individually. At least for the unicast message embodiment, the list of block **502** which is provided to each of a plurality of enabled devices is a device-specific list (though not all such lists are necessarily different; some two or more devices may be enabled using the same channel list). At block **514** each encrypted broadcast or unicast message which has the contact verification signal further comprises a new encryption key anytime a next consecutive broadcast or unicast message which also has the contact verification signal uses different encryption. And finally at block **516**, the different encryption is decrypted by a combination of the new encryption key and an old encryption key.

FIG. **6** is a logic flow diagram which describes an exemplary embodiment of the invention from the perspective of one of the enabled devices **20-23**. FIG. **6** represents results from executing a computer program or an implementing algorithm stored in the local memory of one of the enabled devices **20-23**, as well as illustrating the operation of a method and a specific manner in which the enabled device **20-23** (or one or more components thereof) are configured to cause that overall host electronic device to operate.

Blocks **602** and **604** concern the enabled device (which may or may not be enabled prior to block **602** depending on whether it had a previous list) obtaining its available channel lists and the CVS interval, respectively. At block **602** it receives from an enabling device a list of available license exempt radio channels; and at block **604** it determines an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another. The contact verification signals verify whether the list received at block **602** remains valid.

Further portions of FIG. **6** are directed to certain of the above non-limiting embodiments and implementations. Block **606** tells that the parameter comprises an explicit indication of a number of seconds or a number of beacons between consecutive ones of the contact verification signals. Block **608** specifies that the explicit indication is received from the enabling device in one of a beacon message, a management frame, or system information.

Block **610** tells an alternative embodiment in which the parameter comprises an identifier of the enabled device which is performing FIG. **6**, the enabling device, and a frequency channel. In this case the interval is derived from the said at least one identifier.

Remaining blocks of FIG. **6** relate to encryption. At block **612** the enabled device further receives the contact verification signals in encrypted broadcast messages, or in encrypted unicast messages directed to that enabled device. At block **614** each of the received encrypted broadcast or unicast messages having the contact verification signal further comprises a new encryption key whenever a next consecutive broadcast or unicast message having the contact verification signal uses different encryption. Block **616** has the enabled device further decrypting the next consecutive broadcast or unicast message using the different encryption by combining the new encryption key and an old encryption key.

The various blocks shown in FIGS. **5** and **6** may be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program code stored in a memory. Such blocks and the functions they represent are non-limiting examples, and may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this invention may be realized in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

Reference is now made to FIG. **7** for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practicing the exemplary embodiments of this invention. In FIG. **7** an enabling device **24** is adapted for communication over a wireless link (not specifically shown) with mobile apparatuses, such as mobile terminals, UEs or user devices which may implement the various enabled devices **20**, **21**, **22**. The enabling device **24** may be embodied as a macro eNodeB (a base station of an E-UTRAN system), a WLAN access point, a femto eNodeB, or other type of base stations or access points adapted to provide the license-exempt channel lists and CVSs as detailed above.

In one particular implementation, any of the enabled devices **20**, **21**, **22** may be embodied as a WLAN station STA, either an access point station or a non-access point station. In the case of an access point station, it would function for TVWS and CVS purposes as a dependent/Mode I station enabled by a Mode II device/enabling station **24** and for WLAN purposes as a WLAN access point for any non-access point STAs associated with it under WLAN procedures. In such an embodiment the enabled access point station would not be able to enable any of those associated non-access point STAs for TVWS purposes since it would not be operating as a Mode II or fixed device; for TVWS purposes it is operating only as a Mode I device that is enabled by a different Mode II device **24**. But in this case the enabled access point station may still be able to advertise to its associated STAs and any other devices that are in radio range the identifier of its enabling station **24**.

The first enabled device **20** includes processing means such as at least one data processor (DP) **20**A, storing means such as at least one computer-readable memory (MEM) **20**B storing at least one computer program (PROG) **20**C, and also communicating means such as a transmitter TX **20**D and a receiver RX **20**E for bidirectional wireless communications with the enabling device **24** via one or more antennas **20**F. The RX **20**E and the TX **20**D are each shown as being embodied with a modem **20**H in a radio-frequency front end chip, which is one non-limiting embodiment; the modem **20**H may be a physically separate but electrically coupled component. The first enabled device **20** also has stored in the MEM **20**B at block **20**G computer program code for determining the CVS interval from the parameter according to the various embodiments and implementations above.

The second enabled device **21** similarly includes processing means such as at least one data processor (DP) **21**A, storing means such as at least one computer-readable memory (MEM) **21**B storing at least one computer program (PROG) **21**C, and communicating means such as a transmitter TX **21**D and a receiver RX **21**E and a modem **21**H for bidirectional wireless communications with the first enabled device **20** as well as the other apparatus of FIG. **7** via one or more antennas **21**F. The second enabled device stores in its local MEM **21**B at block **21**G computer program code for determining the CVS interval from the parameter similar to the first enabled device **20**.

Similarly, the third enabled device **22** includes processing means such as at least one data processor (DP) **22**A, storing means such as at least one computer-readable memory (MEM) **22**B storing at least one computer program (PROG) **22**C, and communicating means such as a modem **22**H for bidirectional communication with the other devices of FIG. **7**. The third enabled device **22** also has stored in its local MEM **22**B at block **22**G the computer program code for determining the CVS interval from the parameter.

The enabling device **24** also includes its own processing means such as at least one data processor (DP) **24**A, storing means such as at least one computer-readable memory (MEM) **24**B storing at least one computer program (PROG) **24**C, and communicating means such as a transmitter TX **24**D and a receiver RX **24**E and a modem **24**H for bidirectional wireless communications with enabled devices **20**, **21**, **22** detailed above via its antennas **24**F. The enabling device **24** stores at block **24**G in its local MEM **24**B the parameter or parameters for determining the CVS interval, which it provides to the enabled devices **20**, **21**, **22** associated to it.

At least one of the PROGs **20**C, **21**C, **22**C, **24**C in the respective device **20**, **21**, **22**, **24** is assumed to include program instructions that, when executed by the associated DP **20**A, **21**A, **22**A, **24**A, enable the device to operate in accordance with the exemplary embodiments of this invention, as detailed above. Blocks **20**G, **21**G, **22**G and **24**G summarize different results from executing different tangibly stored software to implement certain aspects of these teachings. In these regards the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM **20**B, **21**B, **22**B, **24**B which is executable by the DP **20**A, **21**A, **22**A, **24**A of the various enabling and enabled devices, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware). Electronic devices implementing these aspects of the invention need not be the entire devices as depicted at FIG. **7**, but exemplary embodiments may be implemented by one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, or a system on a chip SOC or an application specific integrated circuit ASIC.

Various embodiments of the computer readable MEMs **20**B, **21**B, **22**B and **24**B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various embodiments of the DPs **20**A, **21**A, **22**A and **24**A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

Further, some of the various features of the above non-limiting embodiments may be used to advantage without the corresponding use of other described features. The foregoing description should therefore be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention, and not in limitation thereof.

What is claimed is:

1. An apparatus, comprising:

circuitry configured to

receive from an enabling device a list of available license exempt radio channels; and

determine an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, wherein

the contact verification signals verify whether the received list remains valid.

2. The apparatus according to claim **1**, wherein the parameter comprises an explicit indication of a number of seconds or a number of beacons between consecutive ones of the contact verification signals.

3. The apparatus according to claim **2**, wherein the explicit indication is received from the enabling device in one of a beacon message, a management frame, or system information.

4. The apparatus according to claim **1**, wherein

the parameter comprises an identifier of at least one of the apparatus, the enabling device, and a frequency channel, the apparatus being an enabled device, and

the interval is derived from the said at least one identifier.

5. The apparatus according to claim **1**, wherein the circuitry is further configured to receive the contact verification signals in encrypted broadcast messages, or in encrypted unicast messages directed to the apparatus which is an enabled device.

6. The apparatus according to claim **5**, wherein each received encrypted broadcast or unicast message having the contact verification signal further comprises a new encryption key when a next consecutive broadcast or unicast message having the contact verification signal uses different encryption.

7. The apparatus according to claim **6**, wherein the circuitry is further configured to decrypt the next consecutive broadcast or unicast message using the different encryption by combining the new encryption key and an old encryption key.

8. The apparatus according to claim **1**, wherein the apparatus comprises a Mode I enabled device and the enabling device comprises a fixed or a Mode II device.

9. A method comprising:

receiving, by circuitry from an enabling device, a list of available license exempt radio channels; and

determining, by the circuitry, an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, wherein the contact verification signals verify whether the received list remains valid.

10. The method according to claim **9**, wherein the parameter comprises an explicit indication of a number of seconds or a number of beacons between consecutive ones of the contact verification signals.

11. The method according to claim **10**, wherein the explicit indication is received from the enabling device in one of a beacon message, a management frame, or system information.

12. The method according to claim **9**, wherein the parameter comprises an identifier of at least one of an enabled device that executes the method, the enabling device, and a frequency channel, and

the interval is derived from the said at least one identifier.

13. The method according to claim **9**, wherein the method further comprises:

receiving, by circuitry, the contact verification signals in encrypted broadcast messages, or in encrypted unicast messages directed to an enabled device executing the method.

14. The method according to claim **13**, wherein each received encrypted broadcast or unicast message having the contact verification signal further comprises a new encryption key when a next consecutive broadcast or unicast message having the contact verification signal uses different encryption.

15. The method according to claim **14**, wherein the method further comprises:

decrypting, by the circuitry, the next consecutive broadcast or unicast message using the different encryption by combining the new encryption key and an old encryption key.

16. A non-transitory computer readable memory storing a computer executable instructions that, when executed by a computer, causes the computer to:

receive from an enabling device a list of available license exempt radio channels; and

determine an interval, from a parameter received from the enabling device, at which contact verification signals are spaced in time from one another, wherein

the contact verification signals verify whether the received list remains valid.

17. The non-transitory computer readable memory according to claim **16**, wherein the parameter comprises an explicit indication of a number of seconds or a number of beacons between consecutive ones of the contact verification signals.

18. The non-transitory computer readable memory according to claim **17**, wherein the explicit indication is received from the enabling device in one of: a beacon message, a management frame, or system information.

19. The non-transitory computer readable memory according to claim **16**, wherein

the parameter comprises an identifier of at least one of an enabled device, the enabling device, and a frequency channel, the enabled device including the computer, and

the interval is derived from the said at least one identifier.

20. The non-transitory computer readable memory according to claim **16**, wherein the computer program further causes the computer to:

receive the contact verification signals in encrypted broadcast messages, or in encrypted unicast messages directed to an enabled device in which the non-transitory computer readable memory is disposed.

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